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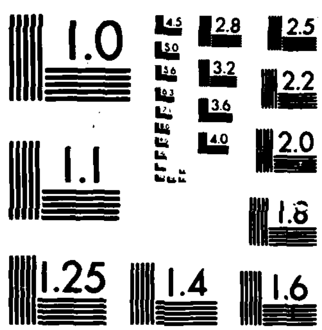
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FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

RELYING ON PROGRESS OF TECHNOLOGY, TO DEVELOP OUR ALLOY STEEL

by

Yang Dong

FOREIGN TECHNOLOGY DIVISION

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Relying on progress of technology, to develop our alloy steel

Yang Dong

Since the establishment of the new People's Republic of China, the national production of alloy steel as well as the technology development have improved very much from almost nonexistent to current status. The annual yield of alloy steel increased from two to three thousand tons in 1949 to the maximum production of two and a half million tons in 1979. We have now more than six hundred alloy steel products. Basic types such as plate, pipe, wire, belt, cake, ring and shape are complete. The quality of alloy steel has improved significantly in recent years also. One hundred and twenty three types of alloy steel products have been recognized to meet national, ministry, province and municipal standards. However, when compared with the requirement of continuous development for national economy and other advanced industrial countries' standards, there still remains quite a gap. Therefore, it is our honor and difficult responsibility to develop a new era of alloy steel production. This work also meets the instruction of Premier Chao to advance our nation's industries of alloy steel and low alloy steel.

I. Current production status and concepts for future development of our country

To increase the proportion of alloy steel in the overall steel production is a very important strategic decision. It will lead to economic development, national defense strength and enhance economic effectiveness. It is most important also to the development of new machinery equipment, replacement and upgrade of civil commercial products as well as the advancement of military industries for national defense. It will help to achieve technology breakthroughs for all categories of national economy.

Based on preliminary forecasts, during the six five-year economic planning periods the requirements from all categories of national economy for alloy steel will greatly increase both in quantities and in types of product. From figure 1 we can see that in the past twenty years, the alloy steel production percentage in all major steel-producing countries has doubled or tripled. Current average percentage reaches approximately 15%. Yet in our country this figure fluctuated around 5%. If we compare our current alloy steel production percentage with those of other countries under equivalent proportion, we are

relatively equal to the United States and Japan. See figure two. However, this only reflects the technical standards from the thirties to the sixties. With today's technological development, more alloy steel is required to fulfill the needs for technical advancement. West Germany in figure 2 represents such a trend. From the sixties to the eighties, overall steel yield has not changed too much yet the percentage of alloy steel increased from 7.7% to 15.1%. Based on this, we can say that our national alloy steel accounts for too low a percentage for this modern era of the eighties.

To compare the gross national product value with the production of alloy steel, from figure 3 we can see all countries' consumption standards. From Fig. 3 it is obvious that our consumption in 1977-1980 was the lowest as compared with all other industrially advanced nations. Relative to Russia, which is self-sufficient in alloy steel, our consumption is merely a half of theirs.

In order to fulfill the need of alloy steel for national economic development, we have to import a certain amount of alloy steel annually.

Major alloy steel composition of our country as well as those of other nations are compared in table 1. Data shows that the proportion of stainless steel in our country is way lower than the proportion of stainless steel production standard in foreign countries. The proportion of high-speed tooling steel and bearing steel are a little bit higher than foreign standards. Alloy structural steel accounts for similar proportion in our country as in foreign nations. Figure 4 shows the analysis between the combined imports from 1976 to 1980 of all kinds of steel and their consumptions. Among them, the imports of stainless steel accounted for almost one half of total consumption. For bearing steel and high-speed tooling steel, the imports stand for 11.1% and 23.2% respectively. It is not hard to tell that our alloy steel production level, when measured against foreign countries, is still very far behind.

The composition of different types of steel material for our country and that of foreign countries are shown in figure 5. It is obvious from the figure that the shape alloy steel product accounts for too great a percentage, while plate, pipe and belt are too low. This is especially true for the

plate material. Reflected from our self-sufficiency rate in stainless steel, it is also a prominent problem that we are short of plate materials. From figure 6 we can see that between 1976 and 1980, only 21% of stainless steel plate was domestically produced while 79% relied on imports.

Stainless steel is a major steel material required in electrical, petrochemical, chemical, civil and military industries. It is expected that by 1985 the total consumption will be doubled from that of 1982. In order to satisfy this domestic requirement, first the quality has to be improved. Second, the proportions of plate, pipe and belt have to be increased to around 70% of total production. Third, the manufacturing cost has to be lowered to further its competitive edge in the market, hence to reduce the import requirement. For example, by employing the annealing outside of the furnace and continuous casting techniques, the cost of stainless steel (type 18-8) can be reduced by 9-12%. The stimulating effects on technology improvements for related departments by extensively introducing these newly and successfully developed steel materials can not be overlooked.

The primary mission to develop bearing steel technology is still the improvement of quality. /4
Generally speaking, steel material quality affects the durability of bearings to 30-50%. Therefore, the improvement of steel material quality will directly influence the economic effectiveness of mechanical, aerospace and agricultural machinery industries. To adjust the steel material type proportion and expand the production of steel pipes will enhance the consumption rate of bearing steel material by at least 10%. Right now steel pipe accounts for 30% of total bearing steel production in Japan. Its consumption rate of steel material reaches 50%. Hence to expand the percentage of pipe's proportion is another important mission to develop bearing steel technology.

There are many reasons to explain the higher percentage of high-speed tooling steel in overall production in China. First, the durability of the tools are not very high. Second, the extra tooling required on machinery parts is also a related issue. Third, the exports of certain tools account for the requirement. For instance, the export of small drilling heads consumed approximately 5,000 tons of steel. It should be noted that the export of alloy steel products is an extension of our advantage with the

abundance of natural resources of colored-metals. The export of ten thousand tons of high-speed steel bar material can generate foreign exchange income of forty two million U.S. dollars. This is equivalent to twice the amount of foreign exchange generated by exporting the pure Tungsten and Molybdenum ores required for this amount of steel material. With ten thousand tons of high-speed steel material, we can manufacture and export common tooling equipment (such as drill heads). The amount of foreign exchange generated will exceed the amount of foreign exchange created by exporting ten thousand tons of steel material by fifty million dollars.

Based on the above discussions, the strategies to develop our alloy steel industries include: improvement of the steel quality; adjust the proportion of product types; lower the manufacturing cost; and continuously increase the overall production. The short-term goal is set to discontinue the imports while keep on expanding the export quantity.

II. Approaches to develop our alloy steel industry

We have to adopt new techniques as well as adjust the current product structure. The purpose is to double the overall production yield and even more for economic effectiveness. The prerequisite, however, is that the energy consumption is not to increase appreciably. To realize the advancement of our alloy steel industry, we feel that following four tasks have to be accomplished.

1. Accelerate the modernization of current technical equipment.

It has been proved from both domestic and international productions that without advanced technical equipment there is no way to manufacture high quality alloy steel. For example, the research and production of bearing steel in China have been conducted from the fifties until the seventies. Although the quality was improved to a certain extent, it was not until the late sixties and seventies that great improvements were achieved. The adoption of electric-residue annealing and out-of-furnace annealing techniques facilitated the quality enhancement (comparisons can be seen on table 2.) The even distribution of carbides in the bearing steel and the spheroidizing problem are the major issues that need to be considered.

If the grain size could be reduced from 1 μm down to 0.56 μm, then the fatigue life span can be extended by a factor of 2.5. We have to work hard on this end to try for a solution.

Foreign famous brands such as SKF of Sweden and Sanmor special steel of Japan rely on special equipment such as those for out-of-furnace annealing; special heat-resistent materials and controllable continuous quenching machines. With these techniques and equipment the quality of bearing steel is significantly enhanced while the life of bearings produced drastically extended. The product, therefore, gains a leading reputation internationally.

Take stainless steel production as another example. Currently China is still using some of the conventional, old machinery. When compared with foreign techniques, there are tremendous differences. These can be viewed from figure 7. According to foreign standard nowadays, not only the exact type of product can ensured, but the cost is greatly reduced. The quality of the steel is again improved.

Take the major equipment for alloy steel production, the electric arc furnace, as another example for discussion. Large-scale as well as high efficiency or even ultra efficiency have been already realized in foreign countries. In China, however, currently used electric arc furnaces are mostly small scale with normal efficiency. These furnaces are not energy-efficient. Capacities are small. They are not suitable for advanced operations such as out-of-furnace annealing and continuous castings. Improvements definitely have to be achieved.

Most of the rolling and pressing equipments for special application steel mills are not modern. Continuous casting technique needs to be extensively pursued. Rolling machinery, especially for plate and pipe has to be modernized. These will mean a lot to the development of our alloy steel industries.

2. Pursue research on technology development and application theory /5

Merely good equipemnt cannot guarantee the production of good quality product. We have imported quite a lot of full sets of equipment since the fifties. We have also designed and fabricated machinery by ourselves. Among all of these only those which have been thoroughly studied eventually provided good products. On the contrary, merely possessing hardware while no software research was performed not only failed to realize expected ef- effectiveness but also turned out to show losses.

Take the development of the jet metallurgic techniques as an example. The French steel research institute (IRSID) has designed and fabricated the powder-spray equipment in the fifties. However, they did not study the technique itself in time. Therefore, the technique did not show its effect until late sixties when the Teson company of West Germany developed the TN method. Significant metallurgic effects were achieved with the TN method hence actual production ability were materialized. Until the middle of seventies the jet nozzle company of Sweden (SL) together with the Dreyfus experiment research institute developed the third and fourth generation of the powder-spray mechanisms. They also conducted theoretical research at the same time thus the technique itself gained further advancement. The sulfur content in steel was therefore able to be lowered down to less than 0.005%. Thus the quality of wire steel was ensured. Through the configuration control of the alloying element, the quality problem of the Z-direction steel which has the directional uniproperty requirement was solved. Our study and application of jet metallurgy started in 1979. First the study on equipment design was pursued. We have been able to develop by ourselves a Chinese-made powder-spray can. We also designed and fabricated four types of jet spray mechanisms. After three years of research on technology and application theory, together with imported know-how, we have been able to gain faster development in areas such as steel water pre-treatment, internal powder-spray within the electric furnace, steel-wrapped powder-spray treatment and iron alloy production. The development scheme of powder-spray treatment system is shown in figure 8. The development of this technique was very important to the enhancement of alloy steel, especially low alloy steel, quality.

It took us five years to perform related research on casting and molding of steel. Most of the research work was concentrated on the study of insulation plate and protection residue. Both design and trial-manufacture were performed. The results were obtained from theoretical studies and practical application. The surface quality of steel casting has been improved while the recovery rate was increased by at least 2%.

In order to further promote the technological development, the following work needs to be done:

(1) Research work on ten segments of the steel industry should be performed including stainless steel, bearing steel, high-speed steel, etc. The prupose is to arrive at the international advanced technical standard of all steel materials within a short period of time. In the mean time we hope to establish a production standard of both Bao Steel and Wu Steel of China to become the leading sample in China. Both feature the high-speed continuous cold rolling.

(2) Study new technologies such as out-of-furnace annealing, jet metallurgy, controlled-rolling and quenching under protected atmosphere. These studies shall privide necessary software tools for the upgrading of old factories.

(3) Study the continuous-casting technique and equipment required for alloy steel, especially the continuous-casting techniques for stainless steel. The successful rate of production should be upgraded to 11-14%. All these will create new opportunities to lower the production cost and energy consumption.

(4) Based on the requirement of the users, new alloy steel materials should be developed. Emphasis should be placed on low-cost, good quality stainless steel to fulfill the requirements from the light industries as well as the chemical industry. Attention should also be given to the development of high-tensity alloy steel and high-grade high temperature alloy steel to match the needs from the defense insustry. For the electronic industry, new sophisticated alloy material has to be developed.

(5) Start research work that is related to the application theory of alloy steel. The theories are supposed to provide directions to enhance the standards of the software technical knowledge.

3. Gradually realize the specific manufacture of alloy steel as a stand-alone industry.

For many years the major steel mills of China have been manufacturing many kinds of product at the same time. Therefore they were not able to concentrate on one or two kinds of specific products. Research and development work were virturally impossible. This turned out to be one of the most important reasons why the technical standard could not be improved. The bearing steel manufacturer of Sweden only fabricates the bearing steel. They have accumulated nearly seventy years' experience to help them gain an international reputation. They have also maintained a leading role in the world all the time. The Eastern Steel corp. of France, on the other hand, devoted their attentions to the production of alloy structural steel. It was because of this that their continuous casting ratio reachs as high as 95%. Our steel industry has the following weaknesses: (1) Some enterprises cannot concentrate to complete an overall production line for one type of steel material. (2) No concentrated efforts were dedicated to primary steel products. (3) Not suitable for new techniques such as continuous casting. (4) No accumulation of experiences and technologies were realized. (5) Complicated management structure for production organizations. We, therefore, advocate that within the six five-year economic planning periods the manufacturing of alloy steel should be specialized.

4. Actively apopt international standard as guideline.

All departments of the civil economy are actively improving. The production of alloy steel can not be satisfied with current 100 percent pass with the old standards. We must gradually upgrade those technical standards that are lower than international ones to meet the foreign requirement. Solutions especially have to be found for the problems such as the unstability of product quality, large fluctuation range on product dimension and lower quality of packing.

In the same time that we are adopting the international standards we should also summarize those specific characteristics of our own product. Every factory shall be based on its product with its own brand name to establish internal quality control criteria. These criteria will match the international requirements also. The purpose of using international criteria as a reference is not only to enhance the domestic products but also to create opportunities to enter the international markets.

III. A few thoughts on the development of alloy steel production.

1. A number of problems will be encountered in the process of developing alloy steel industries. Emphasis should be given to the enhancement of quality and the adjustment of types of product. The increase of production capacity should be a second consideration. The improvement of better quality should be directed towards high purity, high even distribution and high precision. Special attention must be given to provide high precision. In the same time that we try to lower the cost of production, we should also examine the possibility to increase the social benefit.

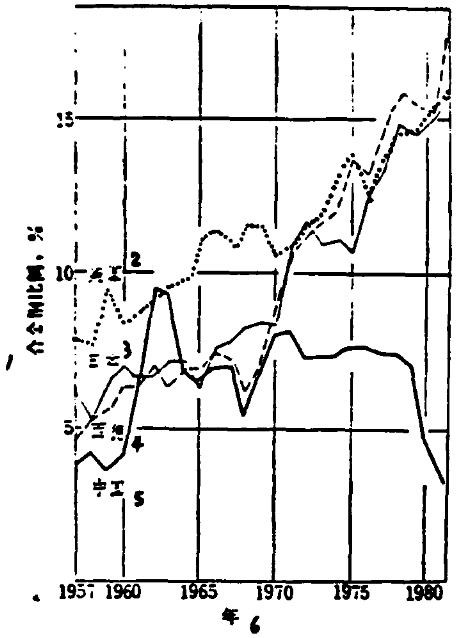
2. Combine the characteristics of our natural resources with the foreign experiences. Research results on the development of new products and new technology should also be related. While developing the new techniques, attention should be given to the realistic situation of our country. Technology with Chinese characteristics should be given priorities.

3. The basis of the development of alloy steel is the research of the application theories of the product. We should concentrate on the study of metallurgic reaction kinetics, the influence of purity on performance, the theory of alloy steel tensity, stress corrosion, friction and friction loss theories.

4. Combine research capabilities. Adjust the technical capabilities of the factories, research institute, universities. Unite the study on stainless steel, bearing steel etc. Concentrate the work on high-efficiency electric arc furnace, out-of-furnace annealing, jet metallurgy,

continuous casting and molding, heat treatment technology, continuous rolling, automation, high speed performance and on-line detection and measurement techniques. Improve the Po Steel Corp. with current capability to imcorporate the rotating furnace as well as the out-of-furnace annealing technology to manufacture alloy steel.

5. Improve market analysis performance. Find outlets for the products of all manufacturing departments. Also pay attention to the development of markets. Use new products to replace the old ones. Provide all industrial departments with newer technology as well as better products.



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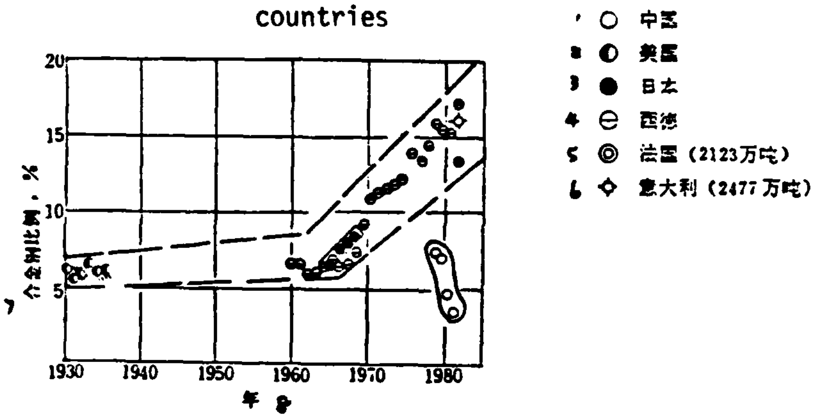
1)Percentage of alloy steel in overall production
2)United States of America
3) Japan
4) West Germany
5) China
6)year

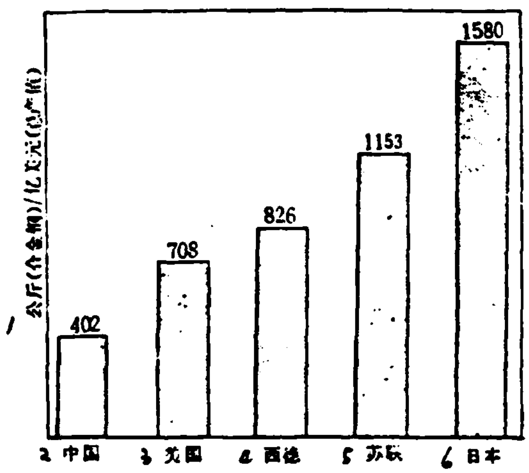
Figure 1 The trend of annual increase of the percentage that alloy steel accounted for in several countries



1)China
2)Unites States of America
3)Japan
4)West Germany
5)France (21.23 million tons)
6)Italy (24.77 million tons)
7)Percentage of alloy steel in overall production

Figure 2 The percentage of alloy steel in overall production while annual capacity was between 30-40 million tons

8)year



1) Kg(alloy steel)/100 million GNP
2) China
3) United States of America
4) West Germany
5) USSR
6) Japan

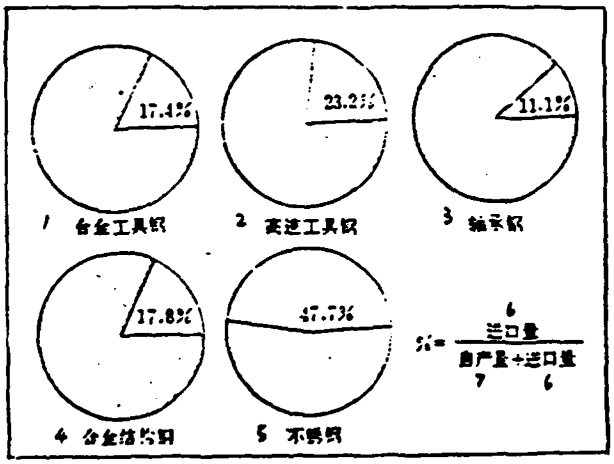
Figure 3 The percentage of alloy steel per 100 million Gross National Product (1977-1980)

3

1 国家	2 项目	3 合金结构钢	4 轴承钢	5 合金弹簧钢	6 不锈钢	7 耐热钢	8 合金工具钢	9 高速钢	10 合计	11 附注
12 中国	15 产量，万吨	84.93	21.24	16.42	5.59	0.48	6.58	3.48	138.72	17 钢材
1979	16 比例，%	3.35	0.84	0.65	0.22	0.02	0.26	0.14	4.5	17 钢材
13 日本	15 产量，万吨	329.7	57.0	31.1	153.9	4.5	8.4	1.5	586.1	17 钢材
1981	16 比例，%	3.62	0.63	0.34	1.69	0.05	0.09	0.016	6.4	17 钢材
14 苏联	15 产量，万吨		995.1		165.4		21.6	12.3	1155.4	18 钢
1975	16 比例，%		6.76		1.18		0.15	0.087	8.2	18 钢

Table 1 Production output and respective apportions in overall capacity of several alloy steels

1) Country
2) Item
3) Alloy structural steel
4) Bearing steel
5) Alloy spring steel
6) Stainless steel
7) Heat-resistent steel
8) Alloy tooling steel
9) High-speed steel
10) Total
11) Remark
12) China
13) Japan
14) USSR
15) Production,10,000 tons
16) Percentage,%
17) Steel material
18) Steel



8 (合金结构钢为1979、1980年数据)

Figure 4 Import quantity of five major categories of alloy steel between 1976 and 1980

1) Alloy steel tooling steel
2) High-speed tooling steel
3) Bearing steel
4) Alloy structural steel
5) Stainless steel
6) Import quantity
7) Domestic production
8) (data for alloy structural steel were 1979/8(

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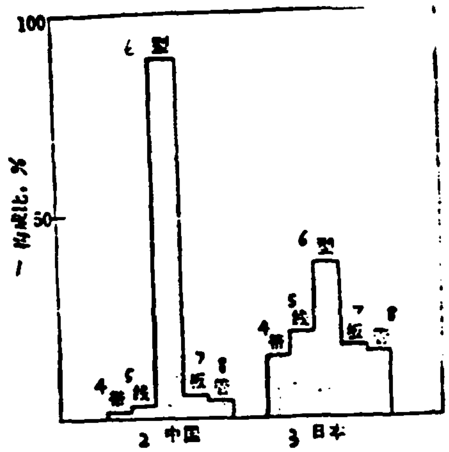

Figure 5 The comparison of compositions of special steel material in China and Japan for 1980

1) Composition, %
2) China
3) Japan
4) Belt
5) Wire
6) Shape
7) Plate
8) Pipe

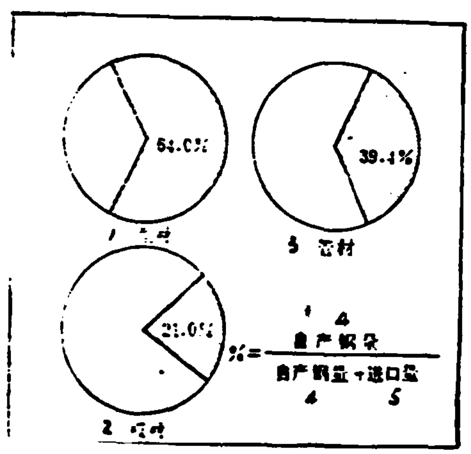

Figure 6 Self-sufficiency percentage for different types of stainless steel materials

1) Shape material
2) plate material
3) Pipe material
4) Domestic production
5) Import

1 工艺方法	4 钢中氢含量 ppm	5 钢中氮含量 ppm	6 钢中氧含量 ppm	7 氧化物夹杂 评级，级	8 疲劳寿命 (推力片)
2 电炉冶炼	5～7	60～80	35～55	～1.5	1.0
3 电炉+炉外精炼	<2.5	50～70	15～20	<1.5	1.3～1.5

Table 2 The effects of different techniques on the quality of stainless steel

1) Techinques
2) Electric arc furnace annealing
3) Electric arc furnace plus out-of-furnace annealing
4) Hydrogen content in steel
5) Nitrogen content in steel
6) Oxygen content in steel
7) Oxides content grading, grade
8) Fatigue life (propulsion thrust flap)

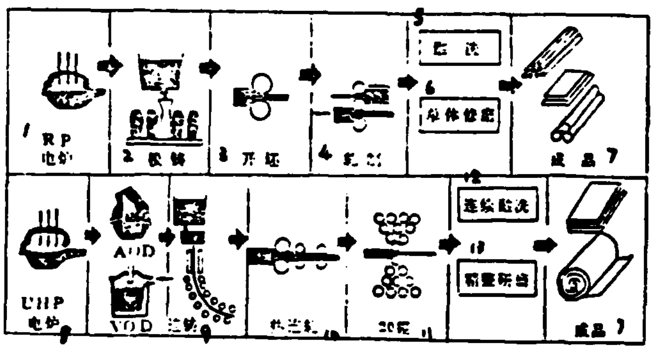

Figure 7 Schematic representations of two different stainless steel production flows

1) RP Electric arc furnace
2) Mold casting
3) Pressing
4) Rolling
5) Acid wash
6) Body tooling
7) Production
8) UHP Electirc arc furnace
9) Continuous molding
10) Hot continuous rolling
11) 20 rotation
12) Continuous acid wash
13) Surface treatment

5

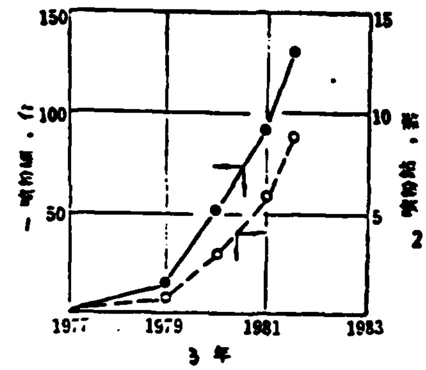

Figure 8 The development status of powder treatment mechanisms in China

1) Powder spray can, units
2) Powder spray station, sets
3) year

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